Atmospheric Dynamics I

g. Shortwave, vorticity and Jet Stream analysis exercise on a 500-mb Heights/ Vorticity chart.

Analyze the chart correctly, as determined by a master solution.

A Sample 500-mb Heights/Vorticity chart

- Solid lines
  - 500-mb height contours.
  - Drawn every 6 dam from a reference 558 dam contour.
- Dashed lines
  - Isopleths of absolute vorticity.
  - Drawn every 2 units.

500-mb Heights/Vorticity chart

- To determine the numerical value of the absolute vorticity
  - Multiply the plotted value by 10^{-5} rad/sec (or 1 rad / 100,000 sec).
  - This number is the absolute vorticity in units of radians per second.
  - Example: the line labeled 12 represents an absolute vorticity of 12 x 10^{-5} rad/sec.

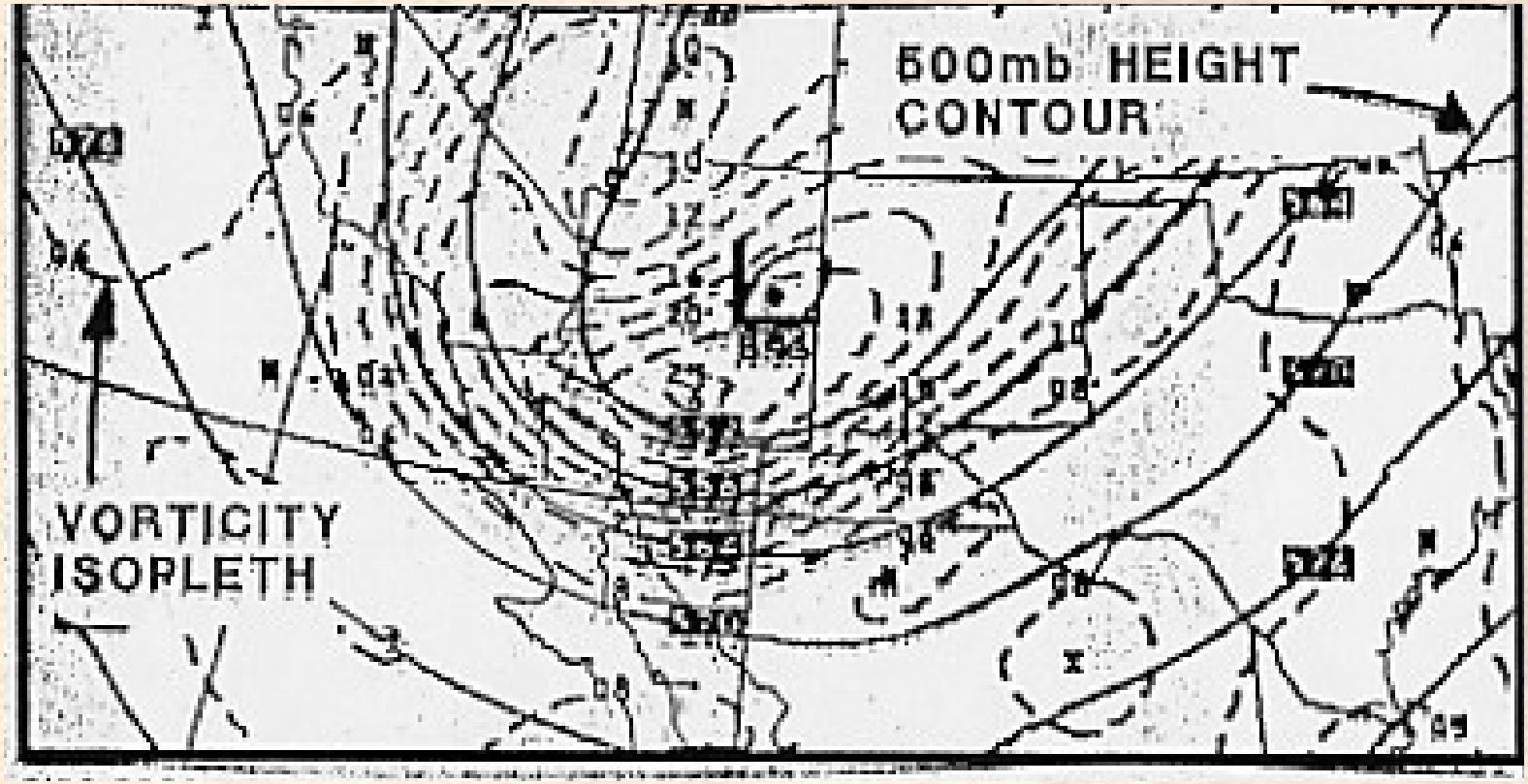
500-mb Heights/Vorticity chart

- Areas labeled "**X**" (Absolute vorticity ma**X**imum)
  - The center of a region of cyclonic (counterclockwise) spin
  - Large absolute vorticity / positive relative vorticity
  - Region of maximum cyclonic vorticity produced by cyclonic shear and/or curvature of the wind.

500-mb Heights/Vorticity chart

- Areas labeled "**N**" (Absolute vorticity mi**N**imum)
  - The center of a region of anticyclonic (clockwise) spin
  - Region of minimum cyclonic vorticity (maximum anticyclonic vorticity) produced by anticyclonic shear and/or curvature of the wind.

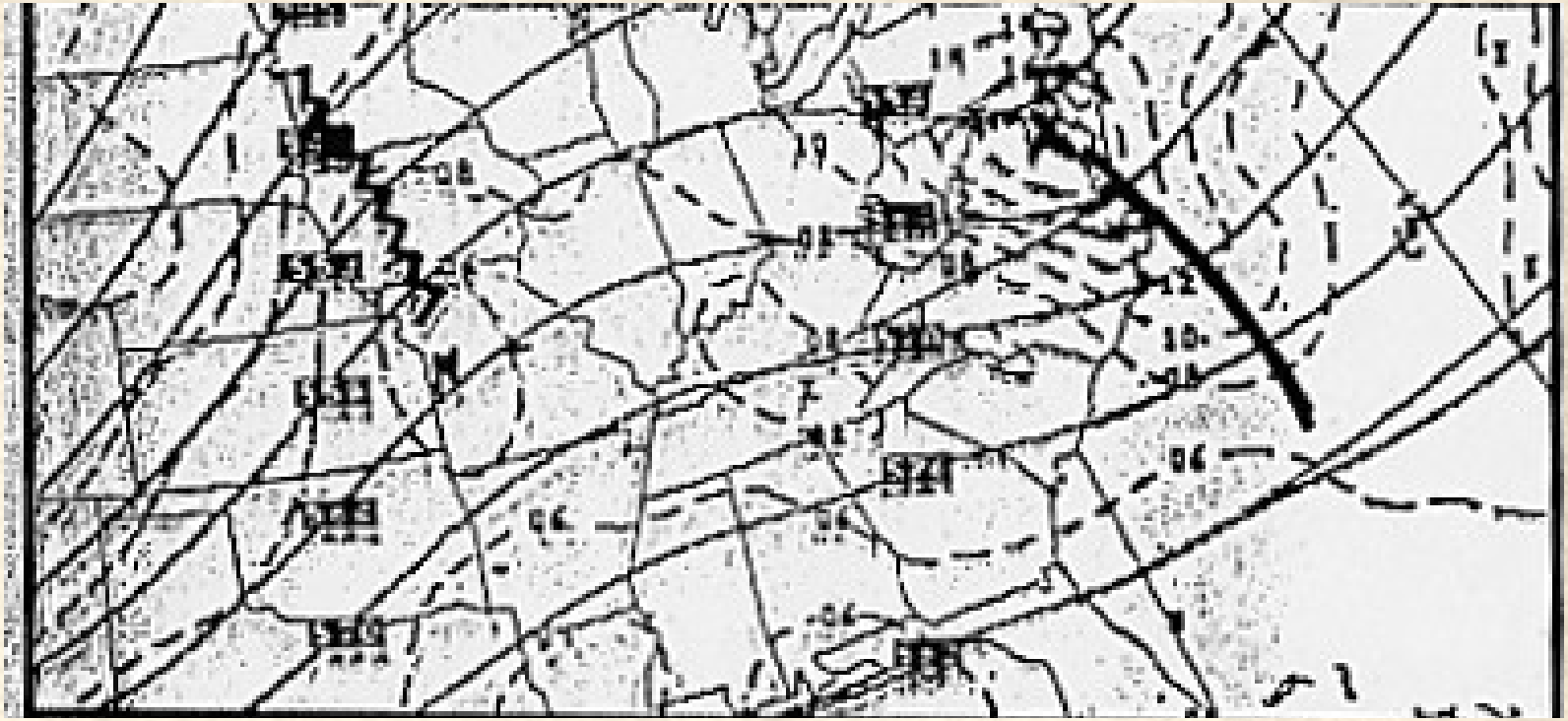
Sample 500 mb Heights/Vorticity Chart



Terminology

- Vorticity Lobe - Region in which vorticity isopleths are elongated.
- Types of Vorticity Lobes
  - Advection Lobe
    - A vorticity lobe in which the axis of the lobe is nearly perpendicular to the wind flow.
    - Curvature of the wind flow is usually large.

Vorticity Advection Lobes



Terminology

- Shear Lobe
  - A vorticity lobe in which the axis of the lobe is nearly parallel to the wind flow.
  - Shear of the wind flow is large.

Vorticity Shear Lobes

Terminology

- In a trough, usually associated with an elongated jet streak
- Usually the lobe’s PVA and NVA regions are far apart

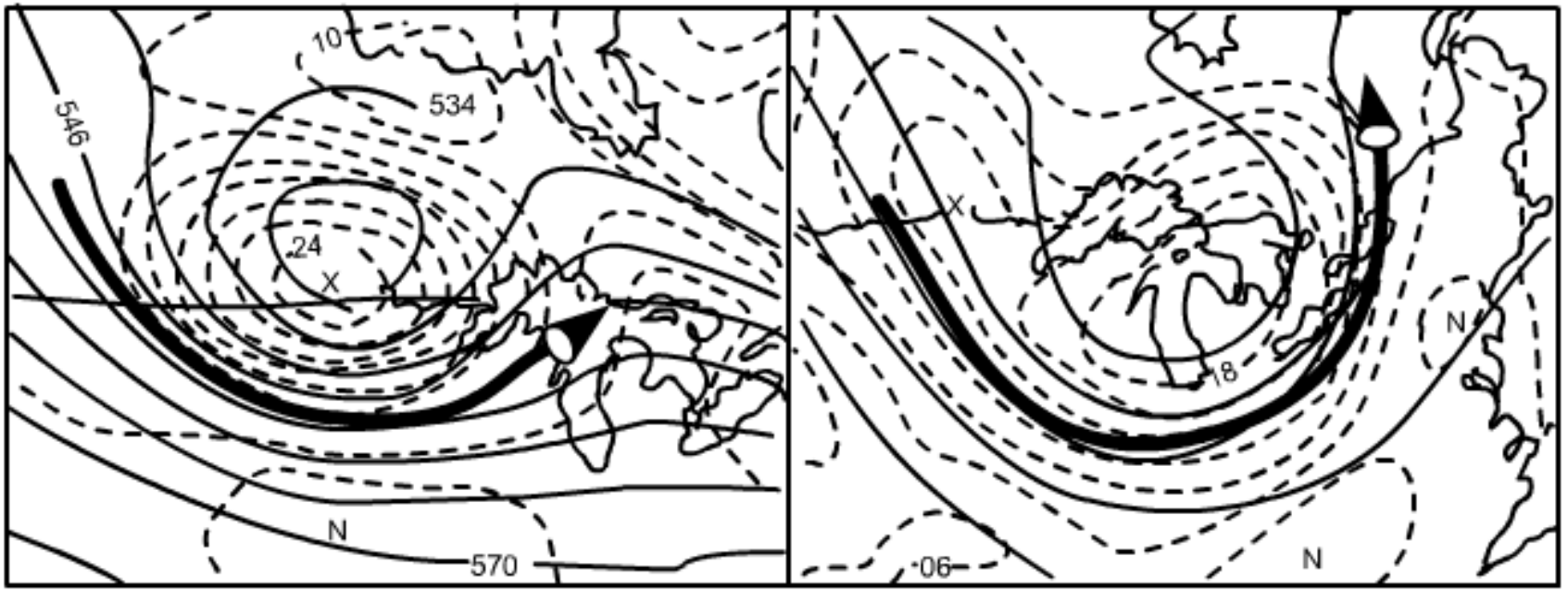
The relationship of the jet stream to vorticity.

- Jet Segments - While the jet stream is typically thought of as a (relatively) continuous band of strong winds around the hemisphere it is useful to further divide the jet stream into two types which have different characteristics.

The relationship of the jet stream to vorticity

- Types of Jet Segments associated with Troughs
  - Channel Jet - A segment of the jet stream where the vorticity isopleths are parallel to the 500-mb height contours.

Channel Jet



The relationship of the jet stream to vorticity

- Vorticity advection may occur near the entrance and exit (i.e., rear and front) regions of the channel jet, but not along the jet axis.
- Jet axis is well defined. A clearly defined band of strong wind exists.
- Jet axis will parallel the contours almost perfectly.

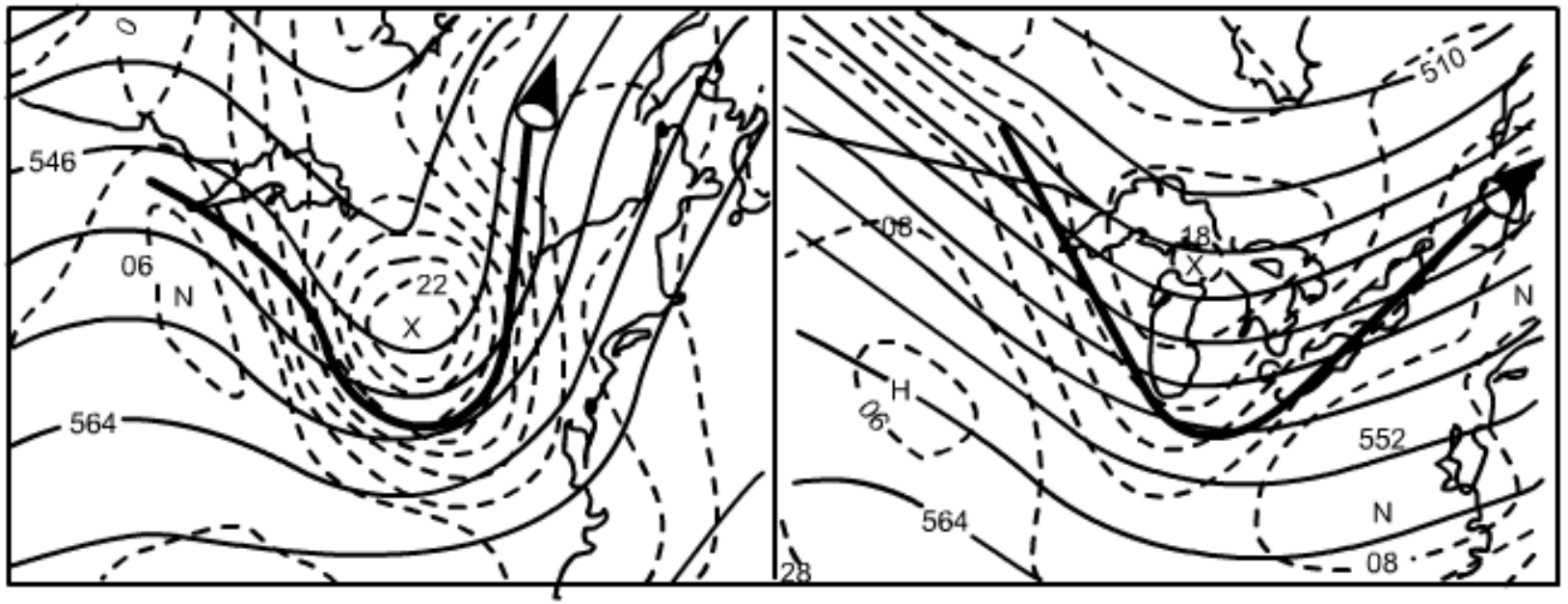
The relationship of the jet stream to vorticity

- Associated with jet maxima (i.e., jet streak). The strongest winds occur in regions where the jet is channeled. The vorticity field is dominated by shear vorticity.

The relationship of the jet stream to vorticity

- Advection Jet - A segment of the jet stream where the vorticity isopleths cross the 500-mb height contours at significant angles.
  - Associated with advection lobes.
  - Vorticity advection will occur along the jet axis.

Advection jets



The relationship of the jet stream to vorticity

- Sometimes, the jet axis will cross the height contours at significant angles. In these cases:
  - In regions of positive vorticity advection (PVA) the jet axis will cross toward **lower** heights (in the +S direction downstream).
  - In regions of negative vorticity advection (NVA), the jet axis will cross toward **higher** heights (in the +S direction downstream).

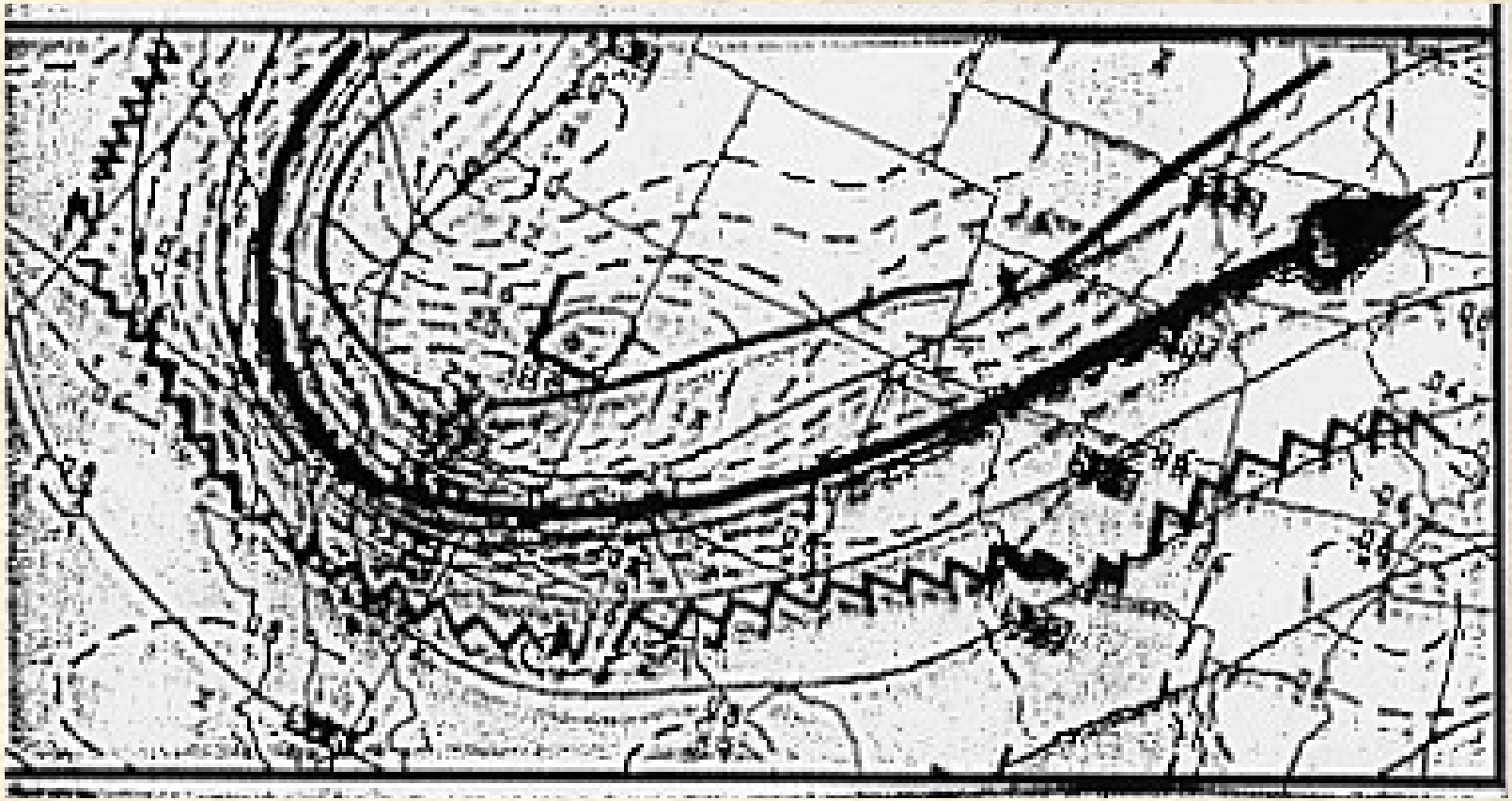
The relationship of the jet stream to vorticity

- Jet stream axis relative to vorticity (Shear Lobe).
  - Positioned with vorticity maxima on the +n (cyclonic shear) side of the jet and vorticity minima on the -n (anticyclonic shear) side of the jet.
  - Shear lobes which represent axes of high absolute vorticity (normally extending from maxima) will be aligned nearly parallel with the cyclonic shear (+n) side of the jet.

The relationship of the jet stream to vorticity

– Shear lobes, which represent axis of low absolute vorticity (normally extending from minima), will be aligned nearly parallel with the anticyclonic shear (-n) side of the jet.

Jet stream Placement on the Vorticity Chart



The relationship of the jet stream to vorticity

- A well defined shear lobe indicates a channeled jet and the presence of a jet max. The jet axis is parallel to the 500-mb contours in this region. A good indication of where possible jet maxima may exist are between ‘X’ and ‘N’ shear lobes where a strong lateral vorticity isopleth gradient is present.

- A well-defined advection lobe indicates an advection jet. The jet axis may either cross or parallel 500-mb contours in this region.

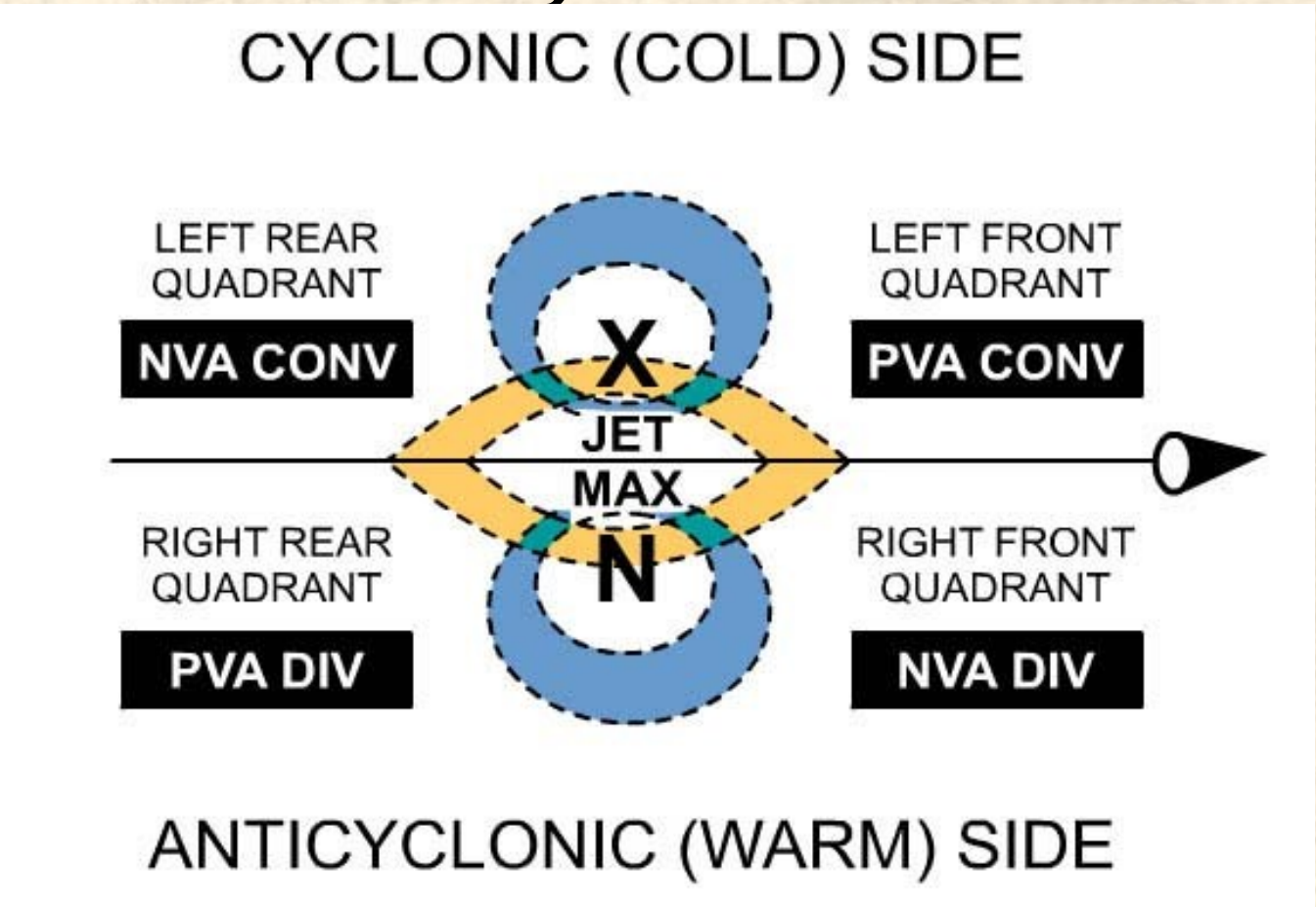
Vorticity Advection and Jet Stream Divergence

- Vorticity advection regions in jet maxima coincide with and jet-induced divergence
- For a jet max in straight-line flow (No curvature), the divergence/ convergence pattern produced by these jet winds occurs in four quadrants corresponding to PVA/NVA.

Vorticity Advection and Jet Stream Divergence

- Straight line flow (no curvature)
  - Left Rear Quadrant = CONV and NVA
  - Right Rear Quadrant = DIV and PVA
  - Left Front Quadrant = DIV and PVA
  - Right Front Quadrant = CONV and NVA

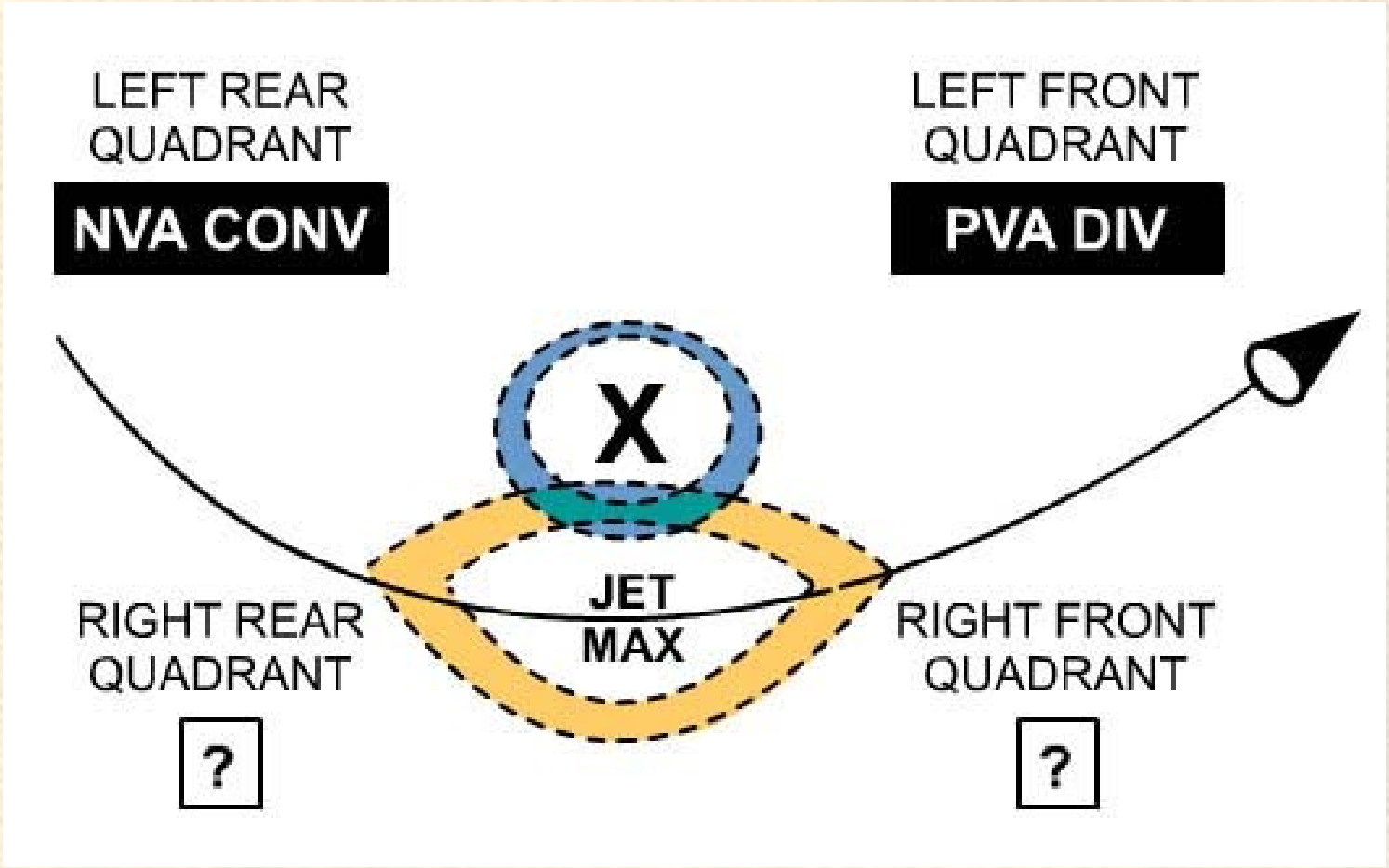
Jet max in straight line flow



Vorticity Advection and Jet Stream Divergence

- Jet max in trough (i.e., cyclonically-curved flow).
  - Left Rear Quadrant = CONV and NVA
  - Left Front Quadrant = DIV and PVA
  - The DIV / CONV and PVA/NVA in the Right Rear and Right Front Quadrants are difficult to assess.

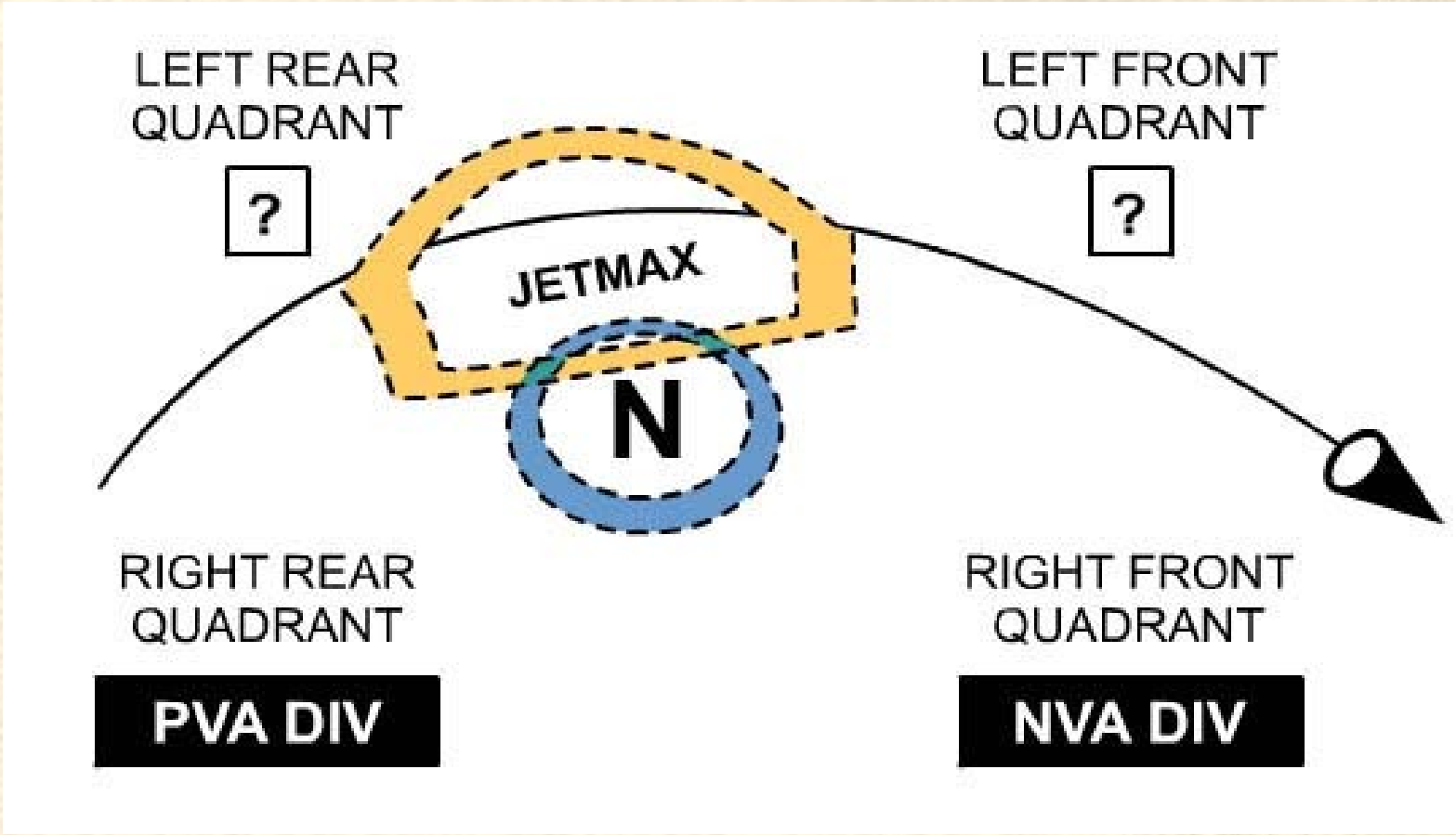
Jet max in trough



Vorticity Advection and Jet Stream Divergence

- Jet max in ridge
  - Right Rear Quadrant = DIV and PVA
  - Right Front Quadrant = CONV and NVA
  - The DIV / CONV and PVA / NVA in Left Front and Left Rear Quadrants are difficult to assess.

Jet max in ridge



Vorticity Advection and Jet Stream Divergence

- Vorticity advection patterns help identify possible regions of CONV/DIV.

Shortwave positioning utilizing vorticity (Advection Lobe only).

- Winds turn cyclonically across a short-wave trough axis, anticyclonically across a short wave ridge axis.
- The turning of the wind is reflected in the vorticity field, since vorticity is (in part) a measure of the curvature of the wind.

Shortwave positioning utilizing vorticity (Advection Lobe only).

- Since short-wave trough and ridge axes are perpendicular to the contours, the vorticity lobe should show up as an elongated pattern oriented nearly perpendicular to the contours.
  - Short-wave troughs are often associated with advection lobes extending from vorticity maxima.
  - Short-wave ridges are often associated with advection lobes extending from vorticity minima.

Shortwave positioning utilizing vorticity (Advection Lobe only).

- Advection lobes are **"clues"** to the existence of a short wave.
  - A short wave should not be drawn in solely because of the presence of an advection lobe.
  - Every short wave may not have a well defined advection lobe associated with it.

500-mb Heights/Vorticity Chart Preparation

- Analyze the vorticity lobes and sketch the axis of all vorticity lobes (advection and shear) in black
  - Vorticity lobes associated with troughs are elongated areas of high absolute vorticity depicted as solid lines. (These usually, but not always, extend from vorticity maxima.)
  - Vorticity lobes associated with ridges are elongated areas of low absolute vorticity depicted as sawtooth lines. (These usually, but not always, extend from vorticity minima.)

500-mb Heights/Vorticity Chart Preparation

- Analyze areas of vorticity advection
  - Regions of **SIGNIFICANT** positive vorticity advection (**PVA**) are outlined and shaded **RED**. **PVA** occurs in regions where the wind blows higher absolute vorticity into a region presently occupied by lower values.
  - Regions of **SIGNIFICANT** negative vorticity advection. (**NVA**) are outlined and shaded **BLUE**. **NVA** occurs in regions where the wind blows lower absolute vorticity into a region presently occupied by higher values.

500-mb Heights/Vorticity Chart Preparation

- Draw the position of the jet stream axis on the vorticity chart in black. Use the technique described earlier.

- APPLICATION: Chart Analysis
- EVALUATION: Progress checks